

## Chapter 4

# Investigating prior knowledge: An introduction to our empirical studies

### Introduction

Within the Centre for Educational Technology and Innovation, the Prior Knowledge States (PKS) project has been investigating the role of students' prior knowledge mainly in the domain of economics.

In this chapter, after a justification for the choice for the domain of economics, we focus on the results of earlier research in relation to prior knowledge and economics. The emphasis will be on secondary and higher educational levels, although studies conducted in other educational levels will be selectively considered when they appear to shed light on the problem heuristically. The literature review is split up in two parts. A first part deals with direct effects of prior knowledge. A second part explores the findings of studies focusing on indirect effects. The findings are commented in a next paragraph and attention is paid to some problems which may merit further investigation.

In the next major part we introduce the reader to our specific approach to study the students' prior knowledge state. A structured discussion of the research context helps to clarify the overall setting in which the following chapters are to be positioned. A variety of research tracks will be followed: students' views on prior knowledge, the use of variables as indicators of prior knowledge, analysis of the quality and impact of the prior knowledge state, etc. These will be worked out mainly in the proceeding chapters.

### Choice for the domain of economics

Our empirical research will focus on the domain of economics. This domain was chosen for several reasons. First, economics is an international science, not differing greatly between countries. Second, the economics faculties of the Open University and the University of Maastricht were both prepared to co-operate in the project. Also the institute for open higher education in Brussels was interested in co-operating in the project. Third, other OTIC research projects (such as the Knowledge Acquisition Support Systems Project) directed their original choice towards economics due to the fact that the University of Tilburg is working on a project concerning unsealing documents in order to create a large database for the domain of economics. Finally, economics seemed a good starting point for future research and applications in business education.

### Inquiries into the direct effects of prior knowledge within economics

There is a paucity of studies bearing directly on the role of prior knowledge in

economics education. The following paragraphs give a summary of these investigations.

Clayton (1964) found a positive association between having taken high school economics and performance in university courses. An inadequacy in his investigation is that he did not control for other differences among the students. Moyer and Paden (1968) discovered that students having completed high school economics in the U.S.A. performed better at the beginning of a university course on economic principles, but that their performance at the end of the course was no better than that of students without the prior study. Moyer and Paden's study was better controlled than Clayton's. Palmer et al. (1979) attempted to improve upon the shortcomings of previous research especially in terms of quality of the dependent variables (the economic tests). Their findings partially replicated Moyer and Paden's in that students with high school economics performed statistically significantly better in tests at the beginning of the course, but slightly (non-significantly) worse at the end, and attained grades in economics that averaged 2.25 percentage points below those of students without prior economics. Palmer et al. conclude that having high school economics may in some cases confuse students or mislead them into over-confidence.

Harbury and Szreter (1970) investigated whether students who have studied economics at school for the G.C.E.<sup>1</sup> 'A'<sup>2</sup> level examination, are handicapped thereby in their achievement in economics and allied subjects at university. They therefore compared the performance of a large group of such students with a control group of students who first began to learn economics as freshmen. The general conclusion of this study was that students having 'A' level economics showed no measurable differences at the beginning or after a university principles course, compared to those who had not.

This conclusion was confirmed by Siegfried (1980). He found that prior formal economics study had no measurable effect on performance in law school economics courses.

Saunders (1980), however, found that students who had taken one or more high school economics courses knew significantly more at the end of a university principles course, even though they reported working significantly fewer hours on the university course.

McKenzie and Staaf (1974) used a wage fund model to develop an economic learning model. They considered achievement in economics as "wealth." The student's score on a TUCE pretest represents the stock of knowledge of economics at the beginning of the course. TUCE stands for "Test of Understanding in College Economics" and is used to approximate the amount of economics knowledge which a student has the disposal of. They assumed that this stock of economics achievement is probably a function of parental background, newspaper availability at home, the level of social science instruction in high school, etc. The student's

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<sup>1</sup> General Certificate of Education

<sup>2</sup> Advanced level

score on a TUCE post test represents total "wealth" at the end of the course, which is composed of the stock of knowledge acquired during the course. The researchers found that brighter students need apply less effort to achieve the same gain in wealth as do less bright students.

Kourilsky and Wittrock (1986) investigated the effects of teaching high school economics in the U.S.A. using modes differing in "familiarity." They conducted what we call an activation study. They found that achievement was greatest when economics concepts were presented first in a familiar verbal mode and then using graphs and other abstract symbol systems. One of the conclusions in this investigation was "...that the type and order of presentation influence learning of concepts in high school economics classes by facilitating or interfering with the generation of relationship between prior knowledge and new information." Prior knowledge in this study appears to refer to anything the student may already know, which helps in learning something new, and also to greater experience or familiarity with some modes of presentation (e.g. verbal explanation) than with others (e.g. graphs or equations).

The study of Voss et al. (1986) was designed to investigate how subject matter knowledge and the use of informal reasoning mechanisms are related to the solving of economics problems by naive individuals (with no formal training in economics) and novice individuals (with training in one or two formal economic courses). The performance of naive individuals is compared to novice individuals with respect to (a) their knowledge of economics and (b) their use of informal reasoning mechanisms. Prior knowledge was compared between naive and novice groups in two ways: by examining performance differences on economics-related tasks and by identifying knowledge related to vocational, avocational and educational experience. A loose interpretation for the absence or presence of reasoning is the extent in which direct or indirect answers are given to a question or problem. Direct answers will generally indicate that a person knows the answer itself or knows an algorithm that holds the answer. Indirect answers are given when a person is not able to produce an immediate answer. In this case the individual may use reasoning mechanisms to generate an answer. Once the presence of a reasoning mechanism is determined, the nature of the reasoning process employed is addressed as formal reasoning (reasoning that an individual engages in when deriving arguments found in formal deduction systems, such as logic or mathematics) or informal reasoning (the processes of reasoning that occur when individuals generate a non-deductive argument and evaluate its soundness).

The authors report that individuals with a college education performed better in relation to economics knowledge than those who did not attend college, and little performance difference was observed between those college-educated individuals who did and those who did not have formal economics training and/or relevant experience.

Bonello, et al. (1984) did research on the effects of mixing students with differing lengths of prior study in the same class. He found that beginning first year university students were "significantly disadvantaged" when placed in a class with experienced second year students. The reasons for this finding were unclear, although one can assume that the pace of instruction was too fast, due to the prior knowledge of the second year students. The authors recommended against such

mixing unless it was justified by other educational considerations.

Reviewing these studies, we can draw the following conclusions. Approximately half of the studies report that students with a higher prior knowledge level perform significantly better than those with a low level. The other studies do not find significantly differing results.

Unfortunately, the quality of high school instruction or actual levels of prior knowledge were mostly not measured and not considered in these studies. First, there is evidence from U.S. research (e.g. Walstad and Soper (1982, 1987)) that high school economics programmes differ markedly in quality. Second, only one study uses a test to assess to real prior knowledge, others use indirect measures or indicators such as having taken high school economics or having studied economics for the 'A' level examination. Perhaps these measures are not the right indicators for prior knowledge. Lephardt (1983) provides us with one possible explanation for this. He addressed learning of economic concepts from a cognitive development framework. He stated that it may well be that the abstract, symbolic (even transformational) ways in which economics is taught in university requires students to employ formal operational reasoning which is not (often) required or available in high school study.

Further, the difficulty of comparing studies at different education levels is likely contribute to the unclear mix of results. Although attention to the quality (and variety) of the dependent variable was made by Palmer et al., a better specification of achievement outcomes (e.g. factual and conceptual learning, etc.) is called for.

The study carried out by Bonnelo could be interpreted as a warning regarding education based on self-study, in the sense that, in providing courses to students with different prior knowledge levels, one should take account of these differences when selecting the materials to be used by individuals.

#### Inquiries into the indirect effects of prior knowledge within economics

Other results may possibly be found when looking at the indirect effects of prior knowledge which come to the surface when investigating interactions between prior knowledge and instruction, for example. Indeed, as Whitener (1989) indicates, notions of individualized instruction could rest partly on the assumption that learning is not simply a function of the learners' backgrounds or of the nature of educational treatments given, but of both interacting to produce new achievement. In this view, prior knowledge represents a variable that may not always directly influence achievement. This may explain why one finds inconsistencies in the direct effects of prior knowledge identified in the literature.

Tobias (1976) proposed that instruction affected new achievement as it interacted with learners' prior achievement or familiarity with the subject matter (Kourilsky and Wittrock (1986)). He also described a range of levels of instructional support that could be needed by or provided to students. Seen in this way, instructional support could minimize the effect of individual differences in prior knowledge. Instructional treatment may differentially affect students, depending upon their

level or type of prior knowledge. An example of this is given in a study by Fraas (1981). "The study indicated that the simulation-gaming method was superior for the students with low pre-course economics knowledge, low SAT scores, and no previous high school economics instruction. The lecture discussion method, however, was superior for students with high pre-course economics knowledge, high SAT scores, and previous high school economics training." This is clearly a disordinal interaction wherein treatment A is better for one group and treatment B for another. It indicates that probably for higher distance education in economics with mostly self-study materials, a reasonable level of prior knowledge is required.

In the earlier-mentioned study of Saunders (1980), high prior knowledge seemed not only to be related to knowing significantly more at the end of a university principles course, but apparently was also related to more efficient use of study time and thus lower time on task.

### Summary and comments on earlier findings within economics

In summary, the educational research literature (general and related to economics) was examined for evidence concerning the role of prior knowledge in economics and business learning. One should be careful in interpreting research results because perhaps not similar groups are compared: in some countries, bright students are discouraged from taking economics at high school because of low status; in this case the brighter group can be the ones not taking economics (Entwistle, 1991 (personal communication)).

A small number of studies were found yielding inconsistent findings for the main effects of high school learning and showing some evidence for the facilitating effect of prior knowledge at university level (table 1). As noted before (chapter 2), prior knowledge is probably not considered, at least outside the laboratory, as a unitary concept. The operationalization of prior knowledge varies from study to study. Clearly the concept of prior knowledge, widely regarded as being the best single predictor of subsequent learning (West and Foster, 1976), needs more research too.

Table 1: Main researchers and findings of prior knowledge effects in economics

<i>Researchers</i>	<i>Level and timing</i>	<i>Effect</i>
Clayton	HS economics      => univ.	+
Moyer and Paden	HS economics      => begin univ. => end univ.	+ ±
Palmer et al.	HS economics      => begin course => end course	+ -
Harbury and Szreter	A-level                => begin univ.  economics            => end univ.	± ±
Siegfried	law school economics	±
Voss et al.	general economics	±
Saunders	HS economics      => end univ.	+
McKenzie and Staaf	HS economics	+
Kourilsky and Wittrock	HS economics	+

Therefore, it can be concluded that the main effects studies of prior knowledge in economics learn us that one should think first about the conceptual problems and that the use of indicators of prior knowledge must be questioned and this perhaps in favour of assessing the real prior knowledge by means of knowledge state tests. In research related to indirect effects of prior knowledge, we found some indications that higher distance education in economics should take the students' prior knowledge into account. It was also reported that students with higher levels of prior knowledge need a shorter time on task. These conclusions will be involved in the design for our empirical research.

## Knowledge state studies: background and methodology

### Background

The initial interest in prior knowledge grew from some striking experiences with university courses, among which the course "Economics and Money" (E & M). When general consideration is given to the achievements of the economics and law students who are expected to study this course, the implicit assumption is often made that economics students possess a better level of prior knowledge. This implicit assumption invokes problems in relation to the "multi-functionality" of the E & M course. Multi-functionality implies that students studying differing disciplines, in this case diploma lines, can make functional use of the same course without encountering special problems (such as delay in completing the course, drop-out, domain-specific problems, etc.). This multi-functionality relies largely on basic assumptions about the role of prior knowledge in studying these courses. Prior knowledge is not expected to play a major role if a course is truly multi-functional. In the view of course developers, law students are claimed to have less prior knowledge than economics students, and this causes specific study problems and poorer examination results.

A second point of interest is the belief that if one can make functional use of his prior knowledge, the learning process becomes more efficient. Third, there is a need to establish whether it is possible to differentiate between those students who are at risk of failing or dropping out and who therefore need guidance, and those students who may be expected to pass without undue problems. If this is considered possible, the instruments for achieving it need to be developed. Certainly in distance teaching it would be a considerable advantage to differentiate from the start. The investigations described in the following chapters were designed to address the problems outlined above. We will begin by describing in general terms the course and the subject-population used in our investigations.

### Subjects in the empirical studies

The research population used here are students taking (or intending to take) diplomas in law or economics who passed at least two courses at the University of Heerlen. These were for the first two ex post facto investigations a total of 2.282 OU students. Further, students of the University of Limburg, Maastricht (UL) studying law or economics are subjects in some of the investigations. This will be indicated in more detail in the specific chapters.

### The Economics and Money (E & M) course

The E & M course has the following objectives:

- to acquire an understanding of quantitative and institutional relationships in the economics of the Netherlands;

- to acquire the ability to make a critical analysis of economic arguments;
- to acquire knowledge of the object of study, the principles and the method of analysis of the microeconomics, the macroeconomics, the comparative economics, financial theory, the theory of international economic affairs and the theory of economic policy;
- with the help of the understanding developed during the course, to be able to follow reports on major national and international economic developments;
- to acquire an understanding of the 'subjective' element in practical economics and the existence of (sometimes opposing) opinions within economics;
- to acquire the ability to manipulate and use economic data as a basis for acquiring a personal opinion on economic phenomena.

The course is considered to be multifunctional since it is part of the compulsory programme of economics and law students. The course is a first level course and represents a nominal study load of 200 hours. The required prior knowledge is only vaguely described: a knowledge of mathematics at higher general secondary education level (first degree comparisons; graphs of first degree comparisons; reading and drawing graphs on the basis of given figures) and an ability to read English at higher vocational education level.

The course comprises 46 modules, grouped in eight blocks. The first block is descriptive. Blocks 2 to 7 represent the theoretical nucleus of the course, and are analytical. The final block, block 8, is methodological. The revision units in this course are made up of texts, articles and quotations and are designed to help the student to check whether he has understood the previous material. These revision units contain no supplementary questions or exercises.

Module 30, belonging to block 5, comprises a computer programme, and offers the student the opportunity to gain extensive practice in solving (systems of) comparisons and to gain an understanding of how economics models function.

The tuition plan assumes that four group meetings will be held. In addition, the tuition plan provides for weekly discussion sessions. Current practice reveals that there are 8 to 12 group meetings a year (De Langen, 1991, personal communication).

### Methodology for research on prior knowledge

As we stated in chapter 3, an overview of what we call PKS research methodology reveals various alternative approaches.

1. Earlier research shows that prior knowledge has a substantial influence on study achievement (Dochy, 1988). Certain researchers have worked along this approach and state that prior knowledge can be measured by looking at a single 'indicator' of prior knowledge (Powell, et al., 1990). But, at a more complex level,



also looking at a set or combination of 'indicators of prior knowledge' could be a relevant approach (Dochy, Segers, and Wijnen, 1990). Such 'indicators' (gender, age, work experience, previous education, etc.) are readily available and easily accessible. It is also expected that these indicators can help to predict achievement of students. If this interrelation is true, it could be worthwhile to look closer at variables that correlate strongly with prior knowledge. The following figure (figure 1) shows the hypothetical and empirically stated interrelations between the concepts prior knowledge, achievement and indicators of prior knowledge. More information about the manipulation of the use and validity of indicators can be found elsewhere (Segers, et al., 1989, Dochy, Segers, and Wijnen, 1990).

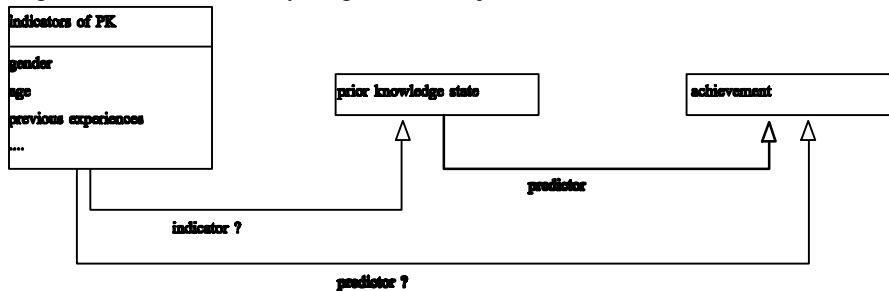


Figure 1: Interrelations between prior knowledge, achievement and indicators of prior knowledge

2. Another view argues that 'indicators' can never give us adequate information on the properties of prior knowledge and thus are not very helpful in enhancing educational practice and students' learning. Researchers, adopting this approach prefer to use tests to measure prior knowledge in a straightforward way (see Bloom, 1976).

3. A third viewpoint states that special prior knowledge tests should be constructed in order to get a full picture of one's prior knowledge. This view starts from the facts that it is yet not clear which personal or contextual variables play a significant role in this context (Ferguson-Hessler, 1989) and research indicates that, if different variables are taken into account, 'prior knowledge' always has the strongest general effect and overrules other variables in descriptive and declarative models (Ethington, 1990; Bruinsma and Geurts, 1988). This pre-dominance of prior knowledge in learning brings Glaser (1987) to the conclusion that the assessment of a person's actual or current knowledge should be stressed or studies should be conducted to assess the knowledge state of the learner.

According to Hively, testing procedures not developed to determine which parts of a domain a student already masters are essentially worthless for helping individuals learn more efficiently. Taking into account students' prior knowledge is a starting point for learning (Glaser, 1981) and for learning skills programmes (Prosser, 1987).

Research reveals that the three approaches come to promising results. For instance: a multiple regression analysis done by Prosser (1987) shows that

using "prior academic ability" as an indicator of PKS can account for 35% of the explained variance (1st approach); measures of prior knowledge (by using special prior knowledge tests) can account for 45% of the explained variance in final achievement scores (3rd approach). Bloom (1976) reported that cognitive entry behaviours as measured by classic achievement tests account for about 50 % of the variance in subsequent achievement (2nd approach). In our view however, the third approach is most relevant due to its possibilities to direct future teaching and learning.

The first approach will be tested in our ex post facto research 2, the third approach will be adopted in the later investigations.

### 'views on prior knowledge

A preliminary investigation was conducted in order to get information concerning the views of students on prior knowledge. Students might give us information which should be taken into account when investigating the prior knowledge problem further. In concrete terms, this meant we were looking for:

- the differences between perceived prior knowledge and objectively determinable variables of prior knowledge;
- the differences between the opinions of the students about the concept 'prior knowledge' and those of experts;
- insight into the fit of courses to the prior knowledge and experience of the students;
- information on the composition of the course orientation booklets (COBs) and their use by students;

For a complete description, the questions and analysis of the results of this study, we refer to Dochy and Steenbakkens (1988). In the next paragraphs, we will describe the research methods and research population and we will shortly comment on the main results.

### Research methods and research population

We used a questionnaire and in-depth telephone interviews. A draft questionnaire was subjected to critical analysis by four content experts, and was finally discussed in the research group.

In-depth telephone interviews use pre-structured questions with open response options and can be regarded as a qualitative method of research. Patton (1980) calls them also 'the standardized open-ended interviews'. This list of questions was used during two experimental interviews to obtain a definitive interview schema.

120 Open University students, who had taken one or more courses in economics, natural sciences or social sciences were approached as respondents.

The students were asked to return the questionnaire with data on their personal background, education and work experience. Further, the students were grouped on the basis of their work experience, in combination with their level of education; in

this way a High Knowledge (HK) group and a Low Knowledge (LK) group were established:

- Less than 10 years work experience and lower than higher vocational education level (group 1=LK).
- More than 10 years work experience and higher vocational education or university level (group 2=HK).

Of the 120 students who were approached to participate in this exploratory study, 40 returned the questionnaire. This is a reasonable amount for a distance teaching university, taking into account a drop-out of 60 % during the study. Based on the data of the management information system (BASIS) of this university, selecting representative samples for all research purposes and taking into account the participation in other investigations, fourteen of these were selected for a telephone interview.

## Results and discussion

Differences between perceived prior knowledge of students and prior knowledge objective determinable variables could not be ascertained. Perceived prior knowledge in the strict sense, assigning a grade to one self for one's prior knowledge, produced virtually no differences between the students, even not between students from the HK group and the LK group. Students did not appear to be able to perceive their prior knowledge in this way. Furthermore it appeared from the further questions in the interview that the students could be brought to a very different view of their PKS in a short period of time. Moreover, students seemed to have rather largely different conceptions of 'prior knowledge', which makes a self-rating procedure invalid. It can be concluded that there is no ground to assume that students can determine their own level of prior knowledge.

From research among experts (chapter 3), the concept of 'prior knowledge state' is defined as comprising declarative and procedural knowledge. In this exploratory study it appears that students' views stress that more than half of the prior knowledge base consists of declarative knowledge (operationalized as 'knowing that', factual knowledge) and only a minor part consists of procedural knowledge (operationalized as 'knowing how', skills)(22.2% to 33.3%). According to the students the PKS comprises also 'experience'(16.7% to 22.2%).

The students were also asked, in view of their experience with the course thus far, whether a person should 'know what' or 'know how to do' before starting the course. Under 'knowing what' we understood: educational level, science subjects, OU foundation course, and 'knowing how' refers to: logical thinking, practical experience, working with figures, skills.

A majority of the students feel that prospective students primarily need a knowledge of facts before they start on a OU course .

Concerning the opinion of students on the connections between the courses and their prior knowledge and experience, it can be concluded that those students who

found the course easy and who indicated the course is not entirely new to them come largely from the HK group.

In respect of the course orientation booklets (COBs), which aim at giving students a correct impression of the course and insight into the prerequisites, it can be concluded that very few students from among the total research population look at the COB before the course. There are students among the LK group who were not even aware of its existence. The HK group knows mainly that the COB is available but they made little or no use of it. They assume that they had the required knowledge. The opinions are divided concerning the prior knowledge requirements stated in the COBs. Some find the requirements too high, others too easy in view of the level of the course. Comments such as 'the COB looks nicer than the course' and 'the COB is virtually the same as chapter 1 of the course' show a great deal has been missed.

Anyway, it can be said that a higher level of education and more work experience (difference HK group and LK group) leads to the students finding a closer connection between the course and the world of experience. Further, the students find the courses easier and they make less use of the COB because they assume that they have a sufficient entry level.

Overall, the students find the prior knowledge an important issue. No differences were found in reported findings in relation to the different domains. All respondents confirm that not meeting prior knowledge requirements has negative consequences for the length of their study programme and their study results: it lasts longer to take the course and further more motivation would be necessary to pass the course or it would be easier to fail. The 'time' variable appears to play an important role in this.

*v* of our investigations

Our subsequent investigations have been set up along a specific track as explained in part 6 of this chapter and pursuing answers for consecutive and related questions as stated in the introduction of this work.

In the first two studies (chapter 5 and 6), we focus on differences in prior knowledge and on 'indicators' of prior knowledge. This implies that we are looking for single variables that can account for differences in prior knowledge in the research population. For an extensive theoretical background and an overview of the applicability of educational indicators we refer to Dochy, Segers and Wijnen (1990).

As this approach is not satisfactory, a new track involving prior knowledge itself instead of indicators becomes the major focus of our studies. This invokes the construction of prior knowledge state tests (PKST). This is described in chapter 7. The PKST are applied in three major studies. This approach will show to meet our demands. More concrete, the results are helpful to detect 'components' of prior knowledge.

These findings inspired us to explore a more advanced level in our research track to analyze the results of the PKST, i.e. the development of knowledge profiles. Since a new conceptual paradigm is used, it implies a elaboration of our theoretical base concerning prior knowledge and knowledge profiles (chapter 10). The study of knowledge profiles results in an operational procedure which is applied in the same chapter.

*"Show me what you know and I will tell you what your strong points and your weak points are".*

Chapter 4

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